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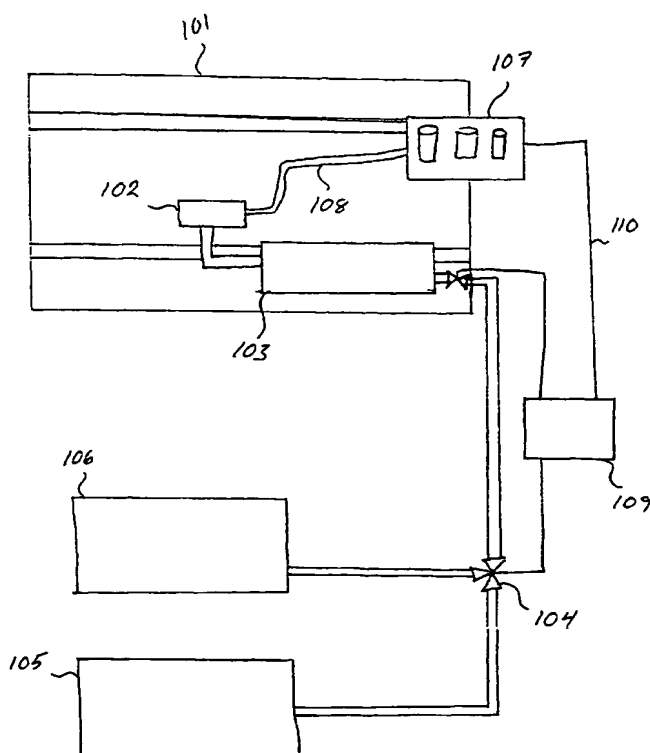
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(54) Title: AUTOMATIC MILK SEPARATION



(57) Abstract: The present invention, relates to separating a first quantity of milk drawn from a milking animal in an automatic milking machine from a second quantity of milk drawn from a milking animal in said milking machine. Comprising the steps of milking an animal using said automatic milking machine, collecting a small representative amount of said milk during said milking, analysing at least a part of said small representative amount of milk using an on-line cell counter for counting the number of cells in said milk, and operating a valve depending on the counted number of cells so that if the counted number of cells are below a threshold said milk is collected in a first container and if said counted number of cells are equal to or above said threshold said milk are directed to either a drain or a second container.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Automatic Milk Separation

TECHNICAL FIELD

The present invention relates to automatic milking machines and more particular to automatically separating milk, with
5 high cell counts, collected with an automatic milking machine from milk with lower cell count.

BACKGROUND OF THE INVENTION

Mastitis is an infection which affects individual cows in a milking herd or even individual teats of a specific cow.
10 Mastitis affects the quality of the milk in a negative way and makes the milk unsuitable for human consumption. Mastitis can be detected by visual inspection, by conductivity measurements, by measuring the NAgase value, measuring the temperature of the milk, measuring the milk flow or the milk
15 quantity from a specific teat. However, most of the above mentioned methods only give rough indications on mastitis. Specifically will conductivity measurements, which is very suitable for automation, only give rough indications.

It is not unlikely that one or more animals, in a herd of
20 milking animals served by an automatic milking machine, may be infected by mastitis. If the milk from an infected animal is collected in the same container as the milk from all other animals substantial economical loss may be incurred since the milk in the container would be ruined or at least be of
25 substantial lower quality.

In automatic milking machines it is vital that the milking machine is automated to the greatest possible extent. For instance would a visual inspection of all milk in an automatic milking machine by an operator remove many of the benefits of
30 the automated milking process.

EP 628 244 B1 discloses a method and an apparatus using a conductivity measurement for obtaining an indication of mastitis and diverting milk based on this indication.

5 WO 98/50577 discloses a cell counter for measuring the somatic cell count in milk as an reliable indication on mastitis.

There thus exists a need in the art to automatically detect mastitis and prohibit milk from infected cows from being collected together with other milk.

SUMMARY OF THE INVENTION

10 It is a main object of the present invention to provide such apparatus and method that eliminates or at least reduces the problems with prior art.

It is in this respect a particular object of the invention to provide such apparatus and method that automatically detects
15 milk with too high cell count and divert that milk either to a drain or a specific container.

These objects among others, according to a first aspect of the present invention, are attained by a method for separating a first quantity of milk drawn from a milking animal in an
20 automatic milking machine from a second quantity of milk drawn from a milking animal in said milking machine. Said method comprises the steps of milking an animal using said automatic milking machine, collecting a small representative amount of said milk during said milking, analysing at least a part of
25 said small representative amount of milk using an on-line cell counter for counting the number of cells in said milk, and operating a valve depending on the counted number of cells so that if the counted number of cells are below a threshold said milk is collected in a first container and if said counted

number of cells are equal to or above said threshold said milk are directed to either a drain or a second container.

These objects among others, according to a second aspect of the present invention, are attained by an automatic milking machine comprising means for separating a first quantity of milk drawn from a milking animal in said automatic milking machine from a second quantity of milk drawn from a milking animal in said milking machine. Said automatic milking machine further comprises a collecting device for collecting a small representative amount of said milk during said milking, an on-line cell counter for analysing at least a part of said small representative amount of milk for counting the number of cells in said milk, and at least a first valve operable to direct said milk depending on the counted number of cells, so that if the counted number of cells are below a threshold said milk is collected in a first container and if said counted number of cells are equal to or above said threshold said milk is directed to either a drain or a second container.

According to a preferred embodiment of the invention a conductivity measurement is taken of the extracted milk and an on-line cell count is only performed if the conductivity of the milk is above a specific threshold.

An advantage of the present invention is that mastitis milk can be detected and diverted automatically without the need of manual intervention.

Further characteristics of the invention and advantages thereof will be evident from the following detailed description of embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description of embodiments of the present invention given hereinbelow and the accompanying Figs. 1-3, which are given by way of illustration only, and thus are not limitative of the present invention.

Figure 1 shows a schematic view of an automatic milking machine according to a preferred embodiment of the invention.

Figure 2 shows a flow diagram of a method according to a preferred embodiment of the invention.

Figure 3 shows a flow diagram of a method according to another preferred embodiment of the invention.

PREFERRED EMBODIMENTS

In the following description, for purposes of explanation and not limitation, specific details are set forth, such as particular techniques and applications in order to provide a thorough understanding of the present invention. However, it will be apparent to one skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed descriptions of well-known methods and apparatuses are omitted so as not to obscure the description of the present invention with unnecessary details.

Figure 1 shows a schematic drawing of an automatic milking machine 100 according to a preferred embodiment of the invention comprising an conventional automatic milking robot 101 having all features conventionally associated with automatic milking robots, such as an animal identification system, automatic application of teat cups, automatic cleaning

of teats and equipment etc., as well as for instance a conductivity measurement means (not shown). Among other conventional things the automatic milking robot 101 comprises a per ce conventional milk meter 102 for measuring the milk
5 drawn from a milking animal. The milk from one animal is conveyed from the milk meter 102 to an end unit 103 for storage of all milk drawn from one animal at a single milking. From the end unit 103 tubing extends to a valve 104 and from the valve 104 to a first milk container 105 and a second milk
10 container 106. The first and second milk containers, 105 and 106, can be conventional milk tanks comprising cooling functionality or could alternatively be simple buckets.

An on-line cell counter 107 is connected to the milk meter 102 through tubing 108. A cell counter suitable for on-line
15 application is more specifically described in WO98/50577 Assigned to Chemometec A/S. The on-line cell counter 107 is operable to take a sample of the milk from the milk meter and analyse this milk sample to obtain a value regarding the somatic cell count of the milk from a specific animal. In this
20 context on-line is regarded to mean that no manual intervention is required to take the milk sample from the milk machine, performe a cell count and report the result to a computer. A computer 109 is connected to the on-line cell counter 107 through a communication means 110 as well as to
25 the automatic milking robot 101 through similar communication means (not shown). Alternatively, the computer 109 may be a computer controlling the automatic milking machine 101. The computer 109 also controls the valve 104 as will be described in more detail below.

30 The function of the automatic milking machine 100 in figure 1 will now be more detailed with reference to figure 2, which shows a flow diagram according to a preferred embodiment of

the invention. When a new milking animal enters the milking robot 101 an identification device (not shown) identifies the animal and reports the identity to the computer 109. The computer 109 keeps record of all milking animals in the herd
5 presently served by the automatic milking machine 100 and whether a cell count of the milk should be taken using the on-line cell counter 107.

Different criteria could be used for this decision. For instance, the farmer may decide that all animals should be
10 tested and thus the computer 109 will order the on-line cell counter 107 to measure the cell count for all animals being milked by the automatic milking machine 100. On the other hand, the farmer may order that only specific animals should be tested, possibly known to be specifically sensitive to
15 infection, or that random animals, according to a specific distribution, should be tested.

If the computer 109 decides that a cell count for the milk drawn from the animal currently present in the automatic milking robot 101 should be performed milk is drawn from the
20 milking meter 102 through the tubing 108 by a pump (not shown). The tubing 108 is a two-way tubing so that milk can be circulated from the milk meter 102 through tubing 108 and the on-line cell counter 107 back to the milk meter 102. By circulating the milk new fresh milk from the animal to be
25 tested will wash away residue milk from a previous tested animal. This will reduce the risk of earlier measurements affecting the result of the present measurement as well as reduce the complexity of the device since no specific means are required for washing the on-line cell counter and the
30 tubing 108 between measurements. The on-line cell counter and the tubing 108 is washed with washing liquid during the normal washing sequence of the milking machine. The pump may be

continuously running or may be ordered to start and stop by the computer 109.

Thus, while the milk from the milking animal is collected in the end unit 103, the on-line cell counter 107 measures the somatic cell count of the milk. The measurement result is reported to the computer 109 through the link 110.

If the somatic cell count is above a threshold the computer controls the three-way valve 104 to direct the milk from the end unit 103 to the second milk container 106 which holds milk of lower quality or milk unsuitable for human consumption or or milk for feeding calves or milk according to any other suitable criteria, or directs the milk from the end unit 103 to the drain. On the other hand, if the somatic cell count is below the threshold the milk is directed to the first milk container which comprises milk of fine quality. Thus an on-line, automatic separation has been achieved based on the somatic cell count of the milk without any manual intervention.

The threshold(s) can be set by the farmer based on his experience from the particular herd. Within EU the dairy limit is 400.000 cells and cell counts below that value may be rewarded with a bonus. If the farmer knows that most animals in the herd has values well below 400.000 cells, he may set the threshold substantially higher, for instance 1.000.000, 2.000.000 or even 3.000.000 cells since the value measured by the dairy will be an average over all the animals in the herd.

With reference to figure 3 showing a flow diagram of another preferred embodiment according to the invention, an animal enters the milking robot 101 and is identified by an identification device (not shown). The identity is reported to the computer 109. Milk is drawn from the animal in a per ce

conventional way and eventually reaches the milk measurement device 102. In this embodiment, the milk measurement device comprises a conductivity measurement device (not shown) for measuring the conductivity of the milk. A high conductivity of the milk is a possible indication of mastitis. The conductivity measurement can be performed at the beginning of the milk sequence or at the middle or towards the end or during the complete sequence. The conductivity measurement device need not necessarily be placed at the milk measurement device but may indeed be placed anywhere the milk passes, such as in a teat cup, in the tubing, in the end unit etc. The result of the conductivity measurement is reported to the computer 109, which may comprise means for processing the results, such as computing an average etc. If the conductivity measurement indicates a conductivity above a second threshold the computer 109 orders the on-line cell counter 107 to perform a somatic cell count on the milk. On the other hand, if the conductivity is below said second threshold no somatic cell count will be performed and the milk will be diverted to the first milk container 105. The second threshold could for instance be 10% or 20% above the average conductivity normally measured for that specific animal.

If the measurement from the on-line cell counter 107 is above a first threshold the computer 109 directs the milk from the end unit 103 to the second milk container 106 and if the measurement indicates a somatic cell count below said first threshold the milk is directed to said first milk container 105.

As an alternative, another pre-indication of mastitis may be used instead of the conductivity measurement. Such indication could for instance be a measurement of the enzyme NAGase (N-acetyl glucosaminidase) where a higher value than normal would

indicate mastitis, the milk flow where a lower value than normal would indicate mastitis, milk temperature where a higher value than normal would indicate mastitis, milk quantity per quarter where a lower value than normal would indicate mastitis etc. A combination of the indicators above could also be used. For instance would a high milk temperature together with a lower milk flow than normal give a more reliable indication of mastitis.

More than two milk tanks may be used for separating the milk and milk can thus be separated in degrees of quality based on somatic cell count. In this case several thresholds are used to separate the milk. If the cell count is below a first threshold it is regarded as being of a first, superior quality and is directed to a first container. If the cell count is above the first threshold but below a third threshold (the second threshold is used for conductivity measurements as in the embodiment above) it is directed to a second container with lower quaility, but which may still be fine enough for feeding calves or other animals. However, if the cell count is above the third threshold the milk is diverted to a third container or to the drain.

It would be advantageous to measure the conductivity in the beginning of the milking sequence since this would give an early indication if a cell count should be performed. If the conductivity is measured at the end of the milking sequence, no milk would longer be present in the milk measurment device 102. The on-line cell counter 107 would then need to fetch milk from the end unit 103. Care need then to be taken so that a representative sample of the milk is taken for the measurement since the milk may form layers.

It will be obvious that the invention may be varied in a plurality of ways. For instance, the invention has only been

described in connection with a robotic automatic milking machine but could equally well be implemented in an automatic milking machine where teat cleaning and teat cup application is performed by hand. Such variations are not to be regarded as a
5 departure from the scope of the invention. All such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the appended claims.

CLAIMS

1. A method for separating a first quantity of milk drawn from a milking animal in an automatic milking machine from a second quantity of milk drawn from a milking animal in said milking machine comprising the steps of:
- 5 - milking an animal using said automatic milking machine,
 - automatically collecting a small representative amount of said first quantity of milk during said milking,
 - analysing at least a part of said small representative amount of milk using an on-line cell counter for counting the number of cells in said first quantity of milk,
10 - operating a valve depending on the counted number of cells so that if the counted number of cells are below a first threshold said first quantity of milk is collected in a first container and if said counted number of cells are equal to or above said first threshold said first quantity of milk are directed to a drain or a second container.
- 15 2. The method according to claim 1, further comprising the additional steps of:
- 20 - measuring a first indicator of mastitis for said first quantity of milk,
 - performing said analysing of at least a part of said representative amount of milk only if said first indicator for said first quantity of milk is above a
25 second threshold.
3. The method according to claim 1 or 2, wherein the step of operating a valve further comprises the step of
- 30 - collecting said first quantity of milk in a third container if the counted number of cells are above a third threshold but below said first threshold and
 - collect said first quantity of milk in said first

container if said counted number of cells are below said third threshold, thereby collecting milk of a first superior quality in said first container, milk of a second quality in said third container and milk of a third quality is directed to said drain or collected in said second container.

4. The method according to claim 2 or 3, wherein said first indicator is one indicator, or a selection of multiple indicators, selected from a group of indicators comprising: the conductivity of said first quantity of milk, the NAgase value of said first quantity of milk, the Urea value of said first quantity of milk, the temperature of said first quantity of milk, the milk flow from said milking animal or the milk quantity from a teat of said milking animal.
5. The method according to any of the claims above, wherein said small representative amount of milk is collected from a milk measuring device.
6. The method according to any of the claims above, wherein said first quantity of milk drawn from one milking animal is collected in an end unit for the duration of performing the somatic cell count.
7. The method according to any of the claims above, wherein said first quantity of milk is collected from a first teat of a milking animal and said second quantity of milk is collected from a second teat of said milking animal.
8. The method according to any of the claims above, wherein said first quantity of milk is collected from a first milking animal and said second quantity of milk is collected from a second milking animal.

9. An automatic milking machine comprising means for separating a first quantity of milk drawn from a milking animal in said automatic milking machine from a second quantity of milk drawn from a milking animal in said milking machine characterised in,
- a collecting device for collecting a small representative amount of said first quantity of milk during said milking,
 - an on-line cell counter for analysing at least a part of said small representative amount of milk for counting the number of cells in said first quantity of milk,
 - at least a first valve operable to direct said first quantity of milk depending on the counted number of cells, so that if the counted number of cells are below a first threshold said first quantity of milk is collected in a first container and if said counted number of cells are equal to or above said threshold said first quantity of milk are directed to a drain or a second container.
10. The automatic milking machine according to claim 9, further comprising a measurement device for measuring a first indicator of mastitis for said first quantity of milk, wherein said on-line cell counter analyses said first quantity of milk if said first indicator for said first quantity of milk is above a second threshold.
11. The automatic milking machine according to claim 9 or 10, wherein said valve is further operable to direct said first quantity of milk so as to:
- collect said first quantity of milk in a third container if the counted number of cells are above a third threshold but below said first threshold and
 - collect said first quantity of milk in said first container if said counted number of cells are below said

third threshold, thereby collecting milk of a first superior quality in said first container, milk of a second quality in said third container and milk of a third quality is directed to said drain or collected in said second container.

12. The automatic milking machine according to claim 10, wherein said measurement device for measuring a first indicator of mastitis is arranged to measure one indicator, or a selection of multiple indicators, selected from a group of indicators comprising: the conductivity of said first quantity of milk, the NAgase value of said first quantity of milk, the Urea value of said first quantity of milk, the temperature of said first quantity of milk, the milk flow from said milking animal or the milk quantity from a teat of said milking animal.

13. The automatic milking machine according to claim 9 - 12, wherein said small representative amount of milk is collected from a milk measuring device.

14. The automatic milking machine according to claim 9 - 13, wherein said first quantity of milk is collected from a first teat of a milking animal and said second quantity of milk is collected from a second teat of said milking animal.

15. The automatic milking machine according to claim 9 - 13, wherein said first quantity of milk is collected from a first milking animal and said second quantity of milk is collected from a second milking animal.

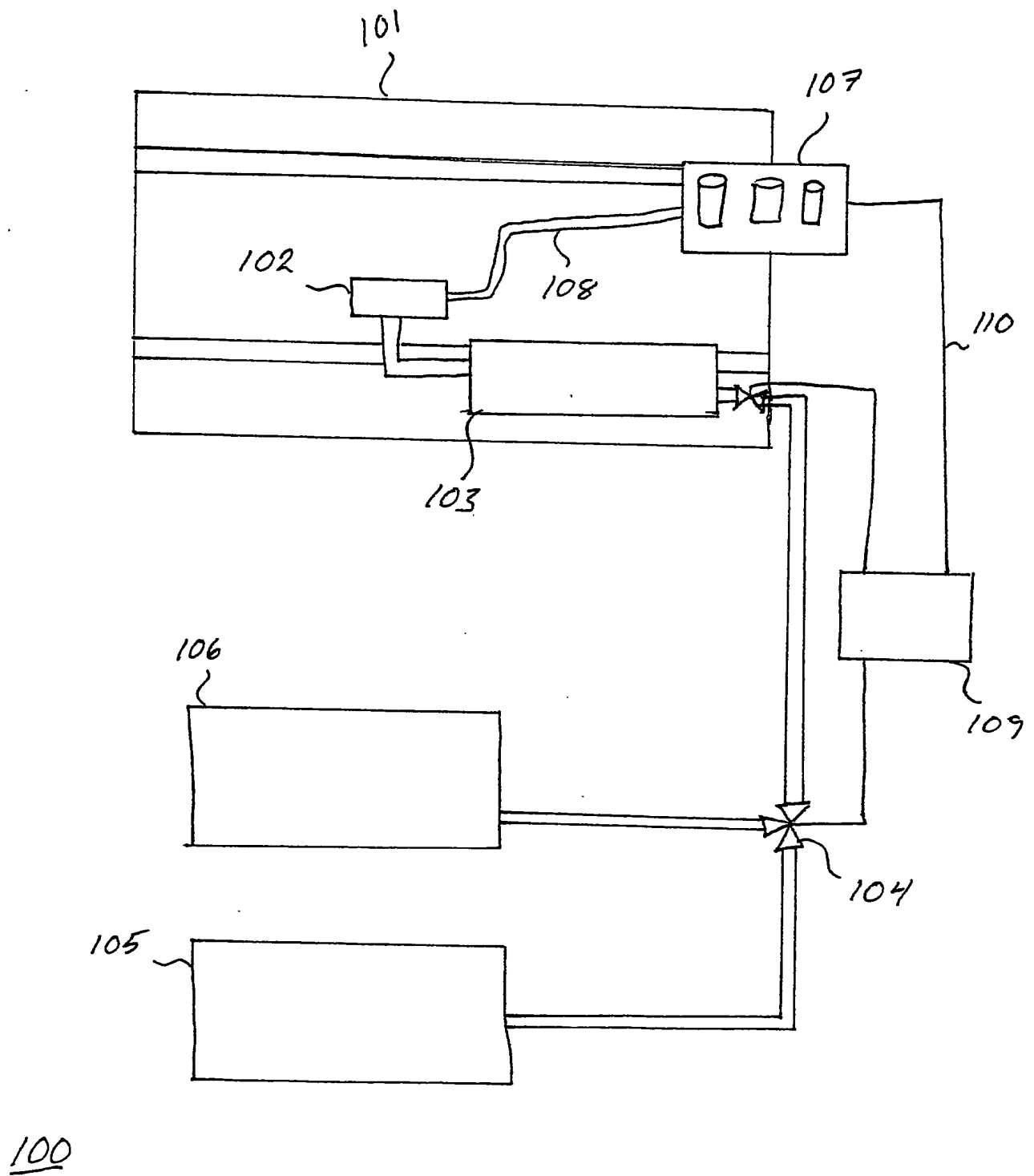


Fig 1

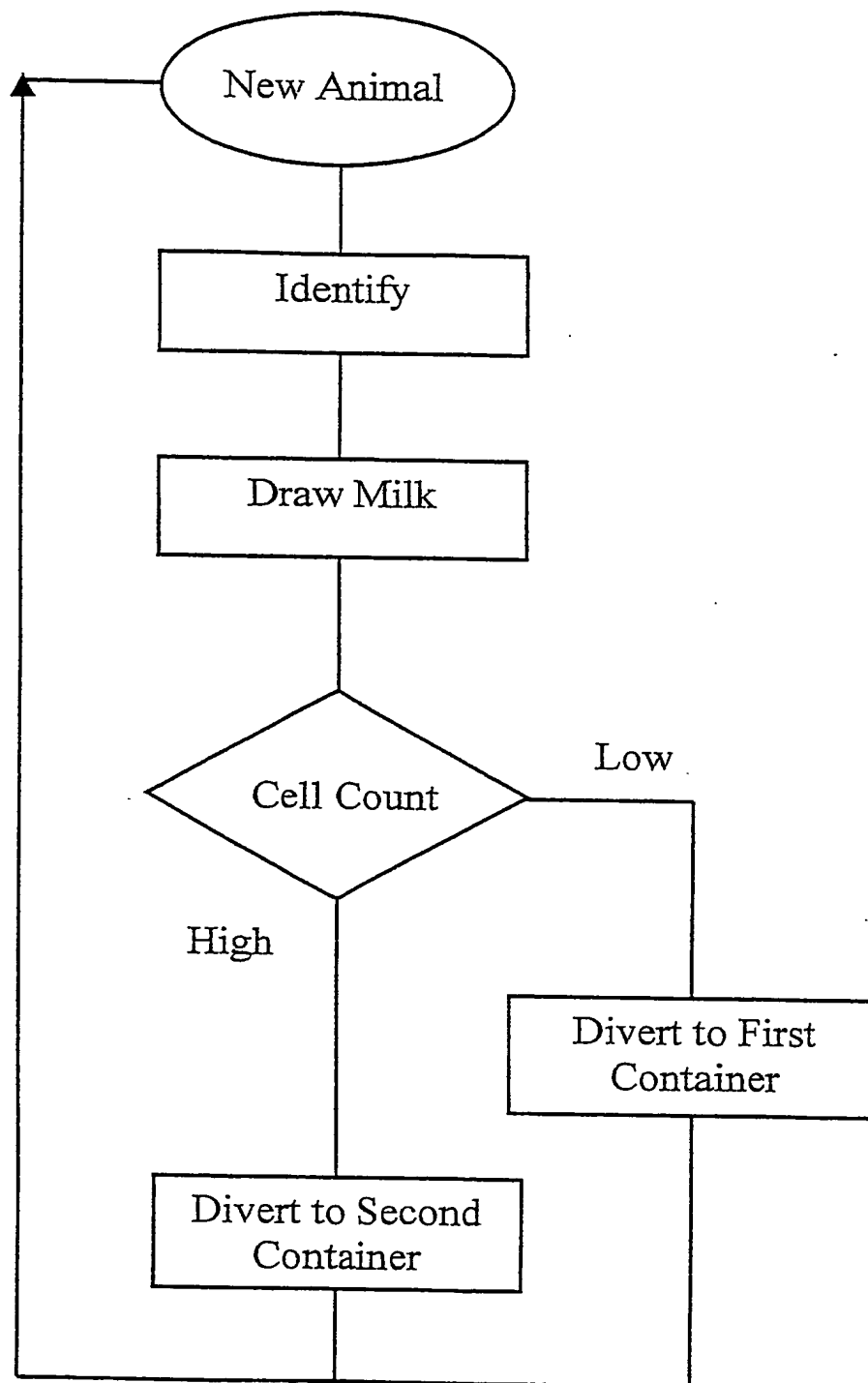


Fig 2

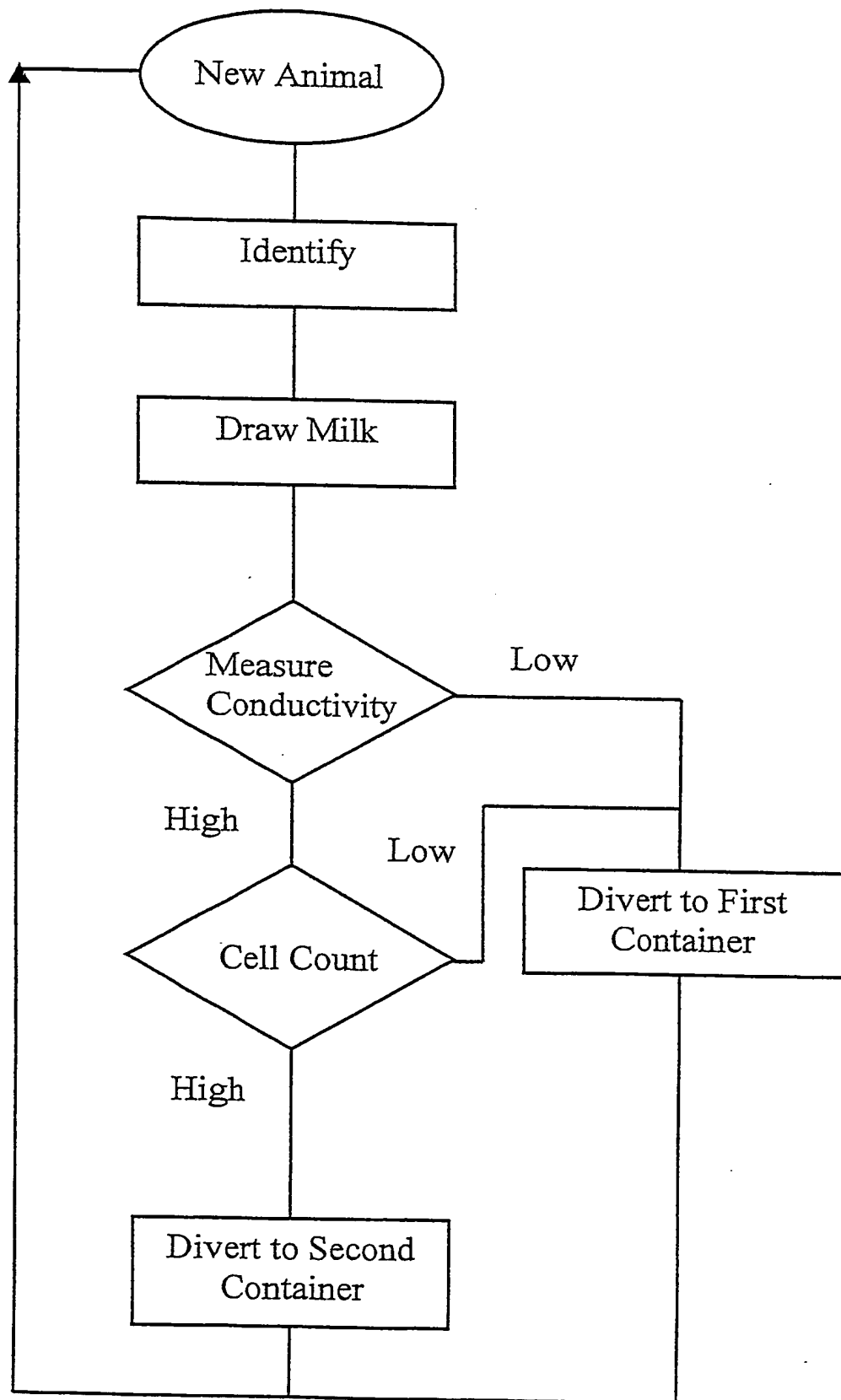


Fig 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 03/00676

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A01J 5/007

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: A01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 0027183 A1 (CHEMOMETEC A/S), 18 May 2000 (18.05.00), page 21, line 23 - line 26; page 22, line 1 - line 3; page 22, line 14 - line 24, claim 1 --	1,3,5-9,11, 13-15
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A	SE 0000179 A (ALFA LAVAL AGRI AB), 23 October 2002 (23.10.02), abstract --	3,11

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

25 July 2003

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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International application No.

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